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Editor's Note

While we might be blanketed in snow for a few more weeks, it's never too early to start thinking about improving your garden or home landscape. Consider signing up for one of the Institute's continuing education classes. Upcoming offerings include *Designing Walks and Steps, Summer Color for Your Garden, Native Plants,* and *Wild Plant Identification.*

Can't wait for spring to get your fix of botanical greenery? Head over to the IES greenhouse, a welcome respite from the cold weather. Managed using integrated pest management, our eco-friendly greenhouse features over 1,300 plants. A sampling of the plant selection includes staghorn ferns, fruit trees, scented geraniums, carnivorous plants, orchids, kitchen herbs, and an array of succulents. The Greenhouse is free to the public and open daily from 9am to 3pm.

The *IES Newsletter* is published by the Institute of Ecosystem Studies, located at the Mary Flagler Cary Arboretum in Millbrook, New York.

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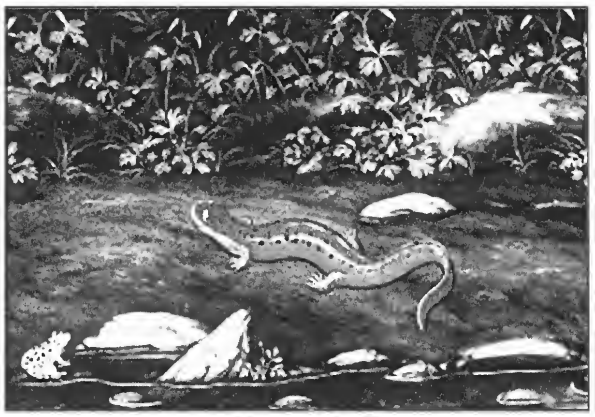
Dining Outside of the Stream



The Endurance of Living Things (The Spring Salamander), Steve Perkins, 1993

Several summers ago, IES post-doctoral Associate Dr. Winsor Lowe, with colleagues, set out to unravel where spring salamanders (*Gyrinophilus porphyriticus)* find their food. Do animals forage for their insect prey in aquatic or in nearby woodland habitats? If they venture out of the water to hunt, does the vegetation they encounter influence their success? Dr. Lowe's findings, recently published in a *Proceedings of the International Association of Theoretical and Applied Limnology* paper, reveal that spring salamanders get a large portion of their diet from terrestrial prey, with dense young forests providing the best dining opportunities. Co-authors included USDA Forest Service Biologist Keith H. Nislow and Institute Director Dr. Gene E. Likens.

For some time, ecologists have understood that terrestrial habitat influences stream food webs. By creating shade, trees alter stream light availability and water temperature. The leaves and branches that fall into streams provide food and shelter for aquatic animals. Water from upland forests drains into streams, enriching them with dissolved nutrients, such as nitrogen and carbon. Dr. Lowe comments, "Past research on how vegetation composition affects aquatic food webs has largely focused on fish. By looking at an animal that is able to move between the stream and the surrounding forest, we sought to gain a broader understanding of how forest change influences stream food webs."

Due to their life history patterns, stream salamanders are well suited to investigating links between aquatic and terrestrial systems. Common to headwater streams in eastern and western North America, salamanders are strictly aquatic as juveniles. At maturity, their range expands to include streamside environments. Adult spring salamanders, which live along the Appalachian Mountains in eastern North America, forage on the land and in the water. The lungless species acquires oxygen through its skin. Because salamanders need to remain moist to respire, forays into terrestrial habitat are likely to be limited by the availability of ground moisture.

During the summer months, Dr. Lowe and colleagues investigated salamander populations in 10 New Hampshire streams. Study sites were limited to streams that had not been exposed to human disturbance, such as logging or road construction, in over 50 years. Terrestrial habitat was surveyed at each site; variables measured included tree diameter, tree type (deciduous or conifer) and canopy coverage. Dr. Lowe explains, "By surveying streamside vegetation, we gained insight into the quality of terrestrial habitat and the influence it might be exerting, through things like shading and leaf litter, on nearby stream environments."

Spring salamanders spend their summer days in refuges in and along streams, where they keep moist and avoid predators such as brook trout and shrews. Surveying the animals involved wading into streams, overturning preferred hiding places, such as rocks and logs, and capturing salamanders with aquarium nets. After their stomach contents were collected through flushing, a non-invasive procedure, captured animals were released. By looking at what the salamanders had eaten, and identifying prey as aquatic or terrestrial, Dr. Lowe and colleagues gained insight into where the animals had foraged for food.

When statistical tests were run to analyze the relationship between salamander diet and forest vegetation structure, Dr. Lowe noticed an interesting trend. Salamanders living in streams near young forests (i.e., with many small trees) were more likely to dine on terrestrial invertebrates than salamanders living near older forests (i.e., with fewer but larger trees).

Dr. Lowe notes, "In our study, forest structure was a good predictor of where salamanders found their food. Salamanders living in streams surrounded by young forests foraged predominantly on terrestrial prey. Animals living near

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Recording the Evolution of an Invasion: An Interview with Dr. David Strayer


Collaboration is at the heart of the Institute's Hudson River research. (L-R) Associate Research Specialist Heather Malcom, Aquatic Ecologist Dr. Michael L. Pace, Manager of Hudson River Studies David Fischer, and Aquatic Ecologist Dr. Stuart E.G. Findlay monitoring river conditions.

This past winter, the National Science Foundation renewed funding for the Institute's long-term research on how the Hudson River is responding to zebra mussels. Introduced in 1991, the invasive bivalves are now the most abundant animals in the river. Institute scientists have generated the longest published record of this invasive species. Thus far, their findings have revealed valuable insight into how zebra mussels have altered both river habitat and the aquatic food web.

As a result of Institute research, the Hudson River is one of the most scientifically scrutinized water bodies in the world. Renewed funding will help support the continued monitoring of the river for the next five years. Recently, I sat down with freshwater ecologist Dr. David L. Strayer, one of the project's lead investigators, to discuss the evolution of zebra mussel research at IES.

How long has the Institute been researching the Hudson River?
The first IES studies began in 1986, when the Institute secured several Hudson River Foundation grants to research the river's lower food web. Drs. Nina F. Caraco, Jonathan J. Cole, Stuart E. G. Findlay and Michael L. Pace spent three years investigating the river's nutrient cycles, aquatic plants, bacterial communities and water chemistry. Three years after they began the project, zebra mussels were detected in New York. Thankfully, by this time Nina had developed a model of the river's phytoplankton communities.

What made her model so important?
Phytoplankton are tiny microscopic plants that form the base of the freshwater food chain. They're also a dietary staple for zebra mussels. By looking at where phytoplankton were abundant, Nina's model helped determine where and how an invasion might impact the river.

When did you become involved?
By 1989, data indicated that zebra mussels were likely to spread to the Hudson, with potentially large ecosystem effects. Nina, Jon, Stuart, and Mike had good information on the lower food web. To have a first-rate invasion study, they needed insight into sediment-dwelling animals in general and zebra mussel populations specifically. I came on board in 1990 to provide this insight. Focused pre-invasion research is rare; ecologists typically only get to react to an existing invasion. Because zebra mussels hit the Great Lakes first, we were able to think ahead.

Were invasion predictions on target?
We expected zebra mussels to invade in the mid 1990's; they arrived in 1991. In many ways, we're lucky they turned up ahead of schedule and in large numbers. Had the invasion happened years down that road, we might not have been able to keep the funding going. Due to the dramatic influx of animals, the project was both fundable and an excellent research opportunity.

What was the most obvious initial effect?
In September of 1992, unable to keep up with zebra mussel's appetites, the river's phytoplankton population crashed. By 1993, between 80-90% of the phytoplankton and small zooplankton in the river were lost. From the onset, we were interested in how the river ecosystem would respond to this profound shift in food resources.

Why is long-term monitoring needed to understand the invasion?
Short-term studies can give misleading or incomplete assessments. In some ecosystems, an invader's impact changes over time due to what ecologists call accommodations and interactions. For instance, accommodation can occur when the species in an ecosystem shift to those that are tolerant of the invader. Prior to the zebra mussel invasion, algal blooms were common in Lake Erie. Post-invasion, they all but disappeared. Recently, *Microcystis* algal blooms have been documented. This species is unpalatable to zebra mussels. The situation is reminiscent of how deer alter forests— the appetite of the invader dictates what survives.

What about interactions?
Think about how tomatoes grow in a garden. Variable weather conditions, such as rain or temperature, influence the quality and quantity of fruit. In the same way, zebra mussel populations may respond differently to changing environmental variables. These trends can take decades to notice.

Why are long-term studies rare?
It's difficult to get funding for long-term monitoring projects. This is unfortunate because the data gleaned from long-term research are essential to shorter-term studies. Also, trends identified through long-term monitoring can drive research efforts. For instance, we have the longest published native mussel record. Our recent surveys indicate that, after over a decade of declining, certain species may be recovering. This is an interesting trend, but one that would have gone unnoticed in the absence of long-term monitoring.

What are some of the variables currently measured?
They range from plankton populations and water chemistry to native shellfish. How we sample is just as important as what we sample. While weekly measurements are centered on several specific sites, every few months the entire reach of the river from Albany to West Point is surveyed. This gives us a much larger context for understanding the invasion.

How abundant are zebra mussels in the Hudson River?
They outweigh all of the other animals in the river. If you took a balance scale and put the zebra mussel population on one side and all the other river animals on the other, the mussels would be heavier.

What keeps them from filling the river?
They are not good at rationing their food! Zebra mussels have a population cycle that looks like a zigzag. Every few years, the population peaks, only to crash. When too many adults survive, they consume food resources to the detriment of their young. The young don't get to eat, they don't mature into the next generation, and population numbers

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Dining, *continued from page 1*

older forests ate more aquatic prey. This relationship was independent of aquatic prey abundance, which suggests that it was either a direct result of forest conditions, or a result of another variable closely related to forest conditions, such as terrestrial prey adundance."

Not all forests are created equal. The young forests where salamanders dined on terrestrial prey are called early successional forests. These forests develop after a disturbance has occurred. While the study forests had been free of human disturbance for 50 years, New Hampshire forests are prone to a suite of natural disturbances, such as ice storms and insect outbreaks. High levels of leaf litter characterize successional forests. Leaves and branches on the ground might provide food and shelter for invertebrates, increasing terrestrial prey abundance. A thick litter layer could also help retain moisture and heat on the forest floor, creating a more hospitable environment for salamanders.

More research is needed to determine the precise reason why salamanders forage so successfully on land in early successional forests. One thing is clear— access to two food pantries may make salamander populations more resilient when confronted with habitat or environmental change. This is especially true for smaller populations of animals living in fragmented landscapes. "By maintaining forested buffers around streams, land managers can preserve the direct connection between stream and forest that favors stream salamander success," Dr. Lowe concludes. ●

Institute Director Honored by the U.S. Forest Service for Science Leadership

The U.S. Forest Service (USFS) honored Institute President and Director Dr. Gene E. Likens with a Science Leadership Award for his pioneering research on watershed ecology. The award was presented at the Forest Service's Centennial Congress, held in Washington, D.C. this past January. Award co-recipients included Drs. F. Herbert Bormann, Robert S. Pierce and Noye M. Johnson.

Together the four scientists founded the long-term investigation of the Hubbard Brook Experimental Forest, located in the White Mountains of New Hampshire. Research performed at Hubbard Brook has revealed valuable insight into how watersheds respond to human-induced environmental change, from air pollution to logging. "Dr. Likens and his colleagues initiated what is now the gold standard of ecological research— long-term sustained studies of nutrient and energy flows. Sound forest management relies on strong unbiased science about how ecosystems function; Dr. Likens has been an important ally in generating this information."

Save the Date: IES Spring Plant Sale May 20-22

The Institute will be holding its annual spring plant sale on May 20th-22nd. Be sure to drop by and take advantage of an array of unique botanical offerings. Selections will include woody plants and perennials. The sale will take place at the Gifford House. Hours are: Friday and Saturday, 10am to 4pm and Sunday, 11am to 4pm. For more information, call 845-677-7600 ext. 309 or 300.

Recording, *continued from page 2*

decrease as adult animals die.

Why do zebra mussels have such a strong ecological impact?
They strip the river of phytoplankton, a valuable aquatic food resource. In the process, they alter light availability. Since the invasion, water clarity in the Hudson is 50% greater. Often, this translates into increased aquatic vegetation near the shoreline. In certain reaches of the Hudson, zebra mussels blanket the river bottom, creating habitat that is inhospitable to native mollusks.

How have native animals responded?
Open water fish that feed on plankton, such as American shad, have declined. Shoreline dwelling fish have thrived. There are concerns about potential avian impacts. Through filter feeding, zebra mussels accumulate contaminants, such as heavy metals and PCBs, in their tissue. In the Great Lakes, waterfowl interrupt their migration to feed on zebra mussels, sometimes spending weeks foraging on the animals. Some people have suggested that populations of Greater and Lesser Scaup, commonly called bluebills, have declined because these birds are picking up contaminants from the zebra mussels that they eat.

What general lesson can be gleaned from the zebra mussel invasion?
Non-resource species can exert strong effects on aquatic ecosystems. Funding focuses on resource species, such as sport fish. In most places, no one is monitoring non-resource species such as zebra mussels or water chestnut. The "catch-22" is that you can't understand what is regulating resource species without understanding the key players in the aquatic environment. In the case of the Hudson River, it would be impossible to understand fish populations without taking zebra mussels into consideration.

The Institute's Hudson River research has been prolific and influential. What do you think has contributed to this?
A number of factors came together at the right time. We had strong pre- and post- invasion data, a rarity in invasion ecology. There were immediate and dramatic invasion effects, grantors were interested, and perhaps most importantly, the Institute had on-staff expertise with the research flexibility to drive the program. Each of us brought something to the table that strengthened the effort and enabled us to study the river as a system.

What will the team explore during the next five years of funding?
The changing distribution of zebra mussels in the Hudson River hints that long-term response might be very different from short-term response. We know enough to know we need to learn more; we are at the second level of exploration. Are native mussels recovering? Will zebra mussels spread into the river's soft sediments? Will river species shift to those that are zebra mussel tolerant? These are just a few of the potential accommodations we would like to investigate. ●

To learn more about the Institute's Hudson River Research Project, visit ***www.ecostudies.org/IES_hudson_river.html***

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Newsletter

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Calendar

CONTINUING EDUCATION

Consider signing up for a continuing education course! Below is a sampling of class offerings. To view the complete brochure please call 845-677-9643 or visit our web site at www.ecostudies.org/cep.html.

Gardening
April 2 (3 Sat.): **Woody Landscape Plants**
April 5 (1 Tues.): **Shade Gardening Know-How**
April 14 (8 Thurs.): **Insect Pests and Diseases of Plants**
April 26 (1 Tues.): **Summer Color For Your Garden**
May 14 (1 Sat.): **Summer Container Gardens**
June 4 (4 Sat.): **Native Plants**
June 18 (1 Sat.): **A Rose is a Rose- Well Not Always**

Landscaping
April 2 (1 Sat.): **Designing with Walks and Steps**

Biology
May 22 (1 Sun.): **Wild Plant Identification**

THE ECOLOGY SHOP

If you are looking for a unique gift come to The Ecology Shop. You will find an assortment of nature and gardening gifts. Many items are fair-trade, recycled, or otherwise earth-friendly, so you can feel good about your purchases. Senior Citizens Days: 10% off on Wednesdays.

IES Summer Ecology Day Camp
NOW ACCEPTING REGISTRATIONS

Does your child enjoy exploring the natural world? Would they like the opportunity to perform hands-on experiments and interact with IES scientists? Consider enrolling them in Ecology Day Camp. Campers will get to explore our 2,000 acre property through ecology experiments, hiking, nature art and ecology games. Summer camp consists of 9 one-week sessions from June 27th through August 26th. To reserve a spot that suits your summer schedule, enroll ahead! For information or to register please call the Education Office at 845-677-7600 ext. 316 or visit www.ecostudies.org.

IES SEMINARS

Free scientific seminars are held at 11am on Fridays in the auditorium from September until early May. Below is a selection of upcoming lectures:

April 1: **"Mammalian defaunation as a global environmental change: biodiverstiy and functional consequences in tropical ecosystems"** *Dr. Rudolfo Dirzo, Stanford University*
April 8: **"What can individual behavior tell us about populations? Two studies: stonefly dispersal and interactions between an endangered salmonid and a non-native trout"** *Dr. Kate Macneale, Northwest Fisheries Science Center*
April 15: **"Water on the web: data, inquiry science, & the internet"** *Dr. Bruce Munson, University of Minnesota*
April 22: **"Reproductive energetics of free-ranging Brazilian free-tailed bats: value added knowledge for assessing ecosystem services"** *Dr. Thomas Kunz, Boston University*
April 29: **"Coevolutionary dynamics of plant-pathogen interactions"** *Dr. Jeremy Burdon, CSIRO-Plant Industry*
May 6: **"Human-fire interactions in the Alaskan boreal forest: human actions in a regional system"** *Dr. Terry Chapin, University of Alaska*

JUNIOR CAMP COUNSELORS

We are now accepting applications for Junior Camp Counselors for the 2005 Summer Ecology Day Camp. Students entering grades 8 and above may apply for this week-long volunteer opportunity. For more information please call Luanne Panarotti at 845-677-7600 ext. 319.

GREENHOUSE

The Greenhouse is a year-round tropical plant paradise and a site for controlled environmental research. Managed using integrated pest management, plants thrive in its pesticide-free environment! Open daily until 3:30pm with a free permit (see HOURS).

HOURS

Summer Hours: April 1 - September 30

Public Attractions: Mon.-Sat., 9-4, Sun. 1-6; closed public holidays. The greenhouse closes at 3:30 daily.
The Ecology Shop: Mon.-Fri., 11-5, Sat. 9-5, Sun. 1-5. *(Please note: The shop is closed Mon.-Sat. from 1-1:30.)*
Required free permits are available at the Gifford House Visitor and Education Center until one hour before closing time.

THE INSTITUTE'S ALDO LEOPOLD SOCIETY

In addition to receiving benefits and discounts, Aldo Leopold Society members are invited to special lectures, excursions and science updates. To learn more, call the Development Office at 845-677-7600 ext. 120.

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... for education, general information and The Ecology Shop:

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The Ecology Shop: 845-677-7600 ext. 309

Street address: Gifford House Visitor and Education Center, 181 Sharon Tpke. (Rte. 44A), Millbrook, NY 12545

For information on current IES public events and attractions, visit the news corner at: www.ecostudies.org
For garden tips, visit: www.ecostudies.org/gardens.html.